BURIED MINE DETECTION
Steven Baker, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Develop the technology of seismic sonar, to detect buried mines.

DoD KEY TECHNOLOGY AREAS: Other (Mine Countermeasures)

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Surf Zone, Mine Countermeasures

PHYSICS OF MINE DETECTION
Steven Baker, Associate Professor
Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Remotely identify buried mines against natural target echoes.

DoD KEY TECHNOLOGY AREAS: Other (Mine Countermeasures)

KEYWORDS: Mine Countermeasures, Seismic Sonar, Rayleigh Waves, Mine Detection, Surf Zone

SEISMIC PROPAGATION AND REFLECTION IN THE SURF ZONE
Steven Baker, Associate Professor
Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Remotely discriminate manmade from natural target echoes.

DoD KEY TECHNOLOGY AREAS: Other (Mine Countermeasures)

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Surf Zone, Mine Countermeasures

INCORPORATING AGENT ORIENTATION IN PHYSICOMIMETICS
David L. Book, Visiting Professor
Department of Physics
Sponsor: Naval Research Laboratory

OBJECTIVE: Adding orientation to the agents, ehick will allow variation in the form of the potential well and permit the resulting global formations to be explored.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communication

KEYWORDS: Physicomimetic, Artifical Physics, Orientation, Agents, Cinfiguration

OSCILLATORY AND RANDOMLY DRIVEN CONTRIBUTIONS TO EARLY-TIME PERTURBATION GROWTH AND RAYLEIGH-TAYLOR SEEDING IS I

David L. Book, Visiting Professor
Department of Physics
Sponsor: Naval Research Laboratory

OBJECTIVE: Add random phase variation (ISI) to the signal of the laser irradiating a target and study the behavior or a single-mode perturbation. Couple damped sonic waves to describe behavior in the shock-compressed plasma. Study role of feedout in initiating r_t on back surface of target.

DoD KEY TECHNOLOGY AREAS: Directed Energy Weapons

KEYWORDS: Rayleigh-Taylor Instability, Seeding, Laser Targets, Feedout, Random Phases

A 100kW FREE ELECTRON LASER DESIGN

W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Simulation and analysis are used to develop a point design for a 100 kW average power free electron laser for ship defense.

SUMMARY: A system design for a high power Free Electron Laser (FEL) was developed for naval applications. The FEL design was made for a specific ship call *SEA ARCHER*, which is a small, fast carrier of the future. Also, numerical simulations were used to characterize the operation of the proposed 100 kW FEL at Thomas Jefferson National Acceleration Facility (TJNAF).

PUBLICATIONS:

Blau, J., Campbell, T., Colson, W.B., Ng, I., Ossenfort, W., Benson, S.V., Neil, G.R. and Shinn, M.D., "Simulations of the 100kW TJNAF FEL Using a Short Rayleigh Length," *Nuclear Instruments and Methods in Physics Research*, 2002, accepted.

Blau, J., Bouras, V., Colson, W.B., Polykandriotis, K., Kalfoutzos, A., Benson, S.V. and Neil, G.R., "Simulations of the 100kW TJNAF FEL Using a Step-Tapered Undulator," *Nuclear Instruments and Methods in Physics Research*, 2002, accepted.

Colson, W.B., "Simulations of the 100kW TJNAF FEL Using a Short Rayleigh Length," *Proceedings of the Twenty-Third International Free Electron Laser Conference*, Darmstadt, Germany, August 2001.

Colson, W.B., "Simulations of the 100kW TJNAF FEL Using a Step-Tapered Undulator," *Proceedings of the Twenty Third International Free Electron Laser Conference*, Darmstadt, Germany, August 2001.

PRESENTATIONS:

Colson, W.B., "Naval and FEL System Constraints," Workshop on Free-Electron Laser Development for Naval Applications, Newport News, VA, June 2001.

THESES DIRECTED:

Ng, I., "A Free Electron Laser Weapon For Sea Archer," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Laser, Directed Energy Weapons

HIGH POWER FREE ELECTRON LASER AT TJNAF
W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Naval Postgraduate School

OBJECTIVE: Characterize the design of the 100kW free electron laser design at Thomas Jefferson National Accelerator Facility, Newport News, VA.

SUMMARY: Numerical simulations were used to characterize the operation of the proposed 100 kW FEL at TJNAF. The FEL is now operating at 2kW average power, and will be upgraded to reach 10kW in the near future. After successful operation at 10kW, the system will be further upgraded to 100kW which is substantially more ambitious. Several design options were found that would not reach the 100kW goal, but some designs would reach the goal. This will help experimentalists consider only those design changes that would be most likely to succeed.

PUBLICATIONS:

Colson, W.B., "Short Wavelength Free Electron Lasers of 2001," *Twenty Third International Free Electron Laser Conference Proceedings*, Darmstadt, Germany, August 2001.

PRESENTATIONS:

Colson, W.B., "Free Electron Lasers of Today," Northern California/Nevada Section of the American Association of Physics Teachers, Monterey, CA, October 2001.

THESES DIRECTED:

Lim, L., "A Concept For CROSSBOW Mine Countermeasures and Terminal Defense Weapons," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Laser, Directed Energy Weapons

HIGH POWER FREE ELECTRON LASERS FOR SHIP DEFENSE
W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Naval Sea Systems Command

OBJECTIVE: An informal course was prepared to teach students the systems engineering associated with the development of a directed energy FEL for naval applications.

SUMMARY: Students were prepared for attending the Workshop on Free-Electron Laser Development for Naval Applications, Newport News, VA (June 2001). Eight NPS students attended the workshop which lasted two days with about 100 attendees. The students were educated on the physics of free electron lasers, accelerators, power systems, cooling systems, naval space requirements, and laser beam propagation through the atmosphere.

PUBLICATIONS:

Colson, W.B., "Short Wavelength Free Electron Lasers of 2001," *Twenty Third International Free Electron Laser Conference Proceedings*, Darmstadt, Germany, August 2001.

THESES DIRECTED:

Polykandriotis, K., "Simulations of the Proposed TJNAF 100 kW Free Electron Laser and Comparison with TJNAF Low Power Experiments," Masters Thesis, Naval Postgraduate School, September 2001.

Ng, I., "A Free Electron Laser Weapon For Sea Archer," Masters Thesis, Naval Postgraduate School, September 2001.

Blau, J., "Multimode Simulation of Free Electron Lasers," Doctor of Philosophy Dissertation, Naval Postgraduate School, March 2002.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Laser, High Energy Laser

TJNAF HIGH POWER FREE ELECTRON LASER RESEARCH

W. B. Colson, Distinguished Professor
Department of Physics
Sponsor: Thomas Jefferson National Accelerator Facility

OBJECTIVE: Simulation and theoretical analysis are used to study the high-average-power free electron laser at Thomas Jefferson National Accelerator Facility, Newport News, VA.

SUMMARY: Numerical simulations were used to characterize the operation of the proposed 10 kW FEL at TJNAF. The FEL is now operating at 2kW average power, and will be upgraded to reach 10 kW in the near future. Several design options were found that would not reach the goal, but some designs would reach the goal.

PUBLICATIONS:

McGinnis, R.D., Blau, J., Colson, W.B., Massey, D., Crooker, P.P., Christodoulou, A. and Lampiris, D., "Simulations of the TJNAF 10kW Free Electron Laser," *Nuclear Instruments and Methods in Physics Research A475*, pp.178, 2001.

Christodoulou, A., Lampiris, D., Colson, W.B., Crooker, P.P., Blau, J., McGinnis, R.D., Benson, S.V., Gubeli,J.F. and Neil, G.R., "Simulations of the TJNAF FEL with Tapered and Inversely Tapered Undulators," *Nuclear Instruments and Methods in Physics Research A475*, pp.182, 2001.

Thomson Jr., R.W., Short, L.R., McGinnis, R.D., Colson, W.B., Shinn, M.D., Gubeli, J.F., Jordan, K.C., Hill, R.A., Biallas, G.H., Walker, R.L., Neil, G.R., Benson, S.V. and Yunn, B.C., "TJNAF Free Electron Laser Damage Studies," *Nuclear Instruments and Methods in Physics Research A475*, pp.625, 2001.

Colson, W.B., Todd, A. and Neil, G.R., "A High Power Free Electron Laser Using a Short Rayleigh Length," *Twenty Third International Free Electron Laser Conference Proceedings*, Darmstadt, Germany, August 2001.

THESES DIRECTED:

Polykandriotis, K., "Simulations of the Proposed TJNAF 100 kW Free Electron Laser and Comparison with TJNAF Low Power Experiments," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Directed Energy Weapons

KEYWORDS: Free Electron Lasers

INFRA-RED RESEARCH - THERMAL IMAGING MODELS
A.W. Cooper, Professor
Department of Physics
Sponsor: Naval Postgraduate School and Naval Sea Systems Command

OBJECTIVE: To improve the modeling of Forward Looking InfraRed (FLIR) systems, particularly the modeling of Minimum Resolvable Temperature Difference for new-generation FLIR systems, to evaluate the potential of polarization filtering in target discrimination range improvement in FLIR imagery, and to compare Tactical Decision Aid FLIR range prediction models for potential joint service use. This project is continuing.

SUMMARY: A computational model constructed to examine the effect of polarization filtering on ranges for detection, recognition and identification has been shown to predict significant increase in detection/recognition range by polarization filtering under certain scenarios and environmental conditions for a generic second generation FLIR system. Various methods have been evaluated for computation of Minimum Detectable Temperature Difference (MRTD) for a generic FLIR system from tabular numerical Minimum Resolvable Temperature Difference (MRTD) data. The current and developing models of MRTD for "next" generation staring imaging systems have been tested by comparison with laboratory measurements on a Mitsubishi IR M500 imager and with a new improved Visibility-based MRTD Model (VISMODII). A numerical simulation of system MRTD (the "Virtual MRTD") developed and used for theoretical interpretation of the influence of system noise and aliasing effects due to sampling in observed image features has shown that spatial sampling effects in array imaging cannot be adequately represented by additional system noise. The existence of image degradation by aliasing below the Nyquist limit has been demonstrated.

PUBLICATIONS:

Celik, M., Kenter, Y., Cooper, A. and Pieper, R., "Aliasing Effects in Thermal Images of Four-bar Patterns below and above the Nyquist Limit," *Proceedings of the 35th Annual Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, CA, 4-7 November 2001.

THESES DIRECTED:

Reyhan, G L. "Targeting and Fire Control System Analysis of the New Turkish Attack Helicopter, The AH-1Z King Cobra," Masters Thesis, Naval Postgraduate School, March 2001.

Colpo, D.J., "Defining Minimum Detectable Temperature Difference (MDT) from Minimum Resolvable Temperature Difference (MRT) in Thermal Imaging Performance Modeling," Masters Thesis, Naval Postgraduate School, June 2001.

Celik, M., "Measurements and Modeling Enhancements for the NPS Minimum Resolvable Temperature Difference Model, VISMODII," Masters Thesis, Naval Postgraduate School, September 2001.

Kenter, Y., "The NPS Virtual Thermal Image Processing Model," Masters Thesis, Naval Postgraduate School, September 2001.

DoD KEY TECHNOLOGY AREAS: Sensors, Battlespace Environments, Modeling and Simulation

KEYWORDS: Atmospheric Optics, Infrared Sensors, FLIR, TDA, MRT, MDT

RESEARCH IN ULTRAVIOLET MULTISPECTRAL IMAGING

D. Scott Davis, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: This proposal solicits funding for the continuation of calibration and field applications of the Naval Postgraduate School Ultraviolet Imaging Spectrometer (NUVIS) and for the development of an improved, next-generation ultraviolet imagine spectrometer.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Sensors, Optics, Ultraviolet, Environmental Monitoring, Remote Sensing

SINKING OF A BODY DUE TO BUBBLES

Bruce Denardo, Associate Professor
Department of Physics
Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVES: A body floats in a fluid when its average density is less than the density of the fluid. If gas bubbles are introduced into a liquid, the average density of the resultant fluid is reduced. If this new density is less than that of the body, then one might think that the body would sink. However, the bubbles also produce upward forces on the body, due to drag produced by the entrained flows in the fluid, and bubbles sticking to the body. It is thus not obvious whether the introduction of the bubbles can cause a floating body to sink, or, if sinking does occur, what the value of the average fluid density is required relative to the density of the body. Further uncertainty exists due to the substantial amount of turbulence that would occur. This possible sinking effect has been suggested as the cause of the demise of some ships. Large deposits of methane gas under the ocean floor could erupt and the resultant bubbles might sink a ship on the surface. Our objective was to measure the average fluid density required to sink a body, and to compare this to the average density of the body for different values of this density. This is necessary if a reliable prediction is to be made regarding the amount of bubbles that a ship can tolerate before sinking. Of future interest is the effect of bubbles on reducing the buoyant force on submerged bodies such as submarines and divers.

SUMMARY: In the third year of this project, publishable data was finally obtained in experiments that accurately measured the critical average fluid density of bubbly water required to barely sink a spherical body. The average density of the body was varied from 0.99 to 0.75 the density of water. Bubbles were generated over the entire cross section of the water column, which we refer to as a *closed* environment. Our theory assumes a "shadow" region directly above the body where there are no bubbles, and neglects any drag or other possible forces other than static buoyancy. The experimental data are in reasonable agreement with the theory for low airflow rates. At greater airflow rates, the experimental average fluid density is less than the predicted value, which may be due to bubbles entering the shadow region as a result of turbulence. Bubbles were also investigated in an *open* environment, which more accurately models the situation in an ocean. In this case, there was expected to be a much greater upward drag force on the body due to circulatory flow. However, the preliminary experiments indicated that this is not true. Further investigations are needed to resolve this.

DoD KEY TECHNOLOGY AREAS: Other (Fluid Dynamics)

KEYWORDS: Fluid Density, Gas Bubbles, Bubbly Water

DEVELOPMENT OF HIGH-PRESSURE MINIATURIZED THERMOACOUSTIC REFRIGERATION PROTOTYPE

Thomas J. Hofler, Associate Professor
Department of Physics
Sponsor: Rockwell Science Center

OBJECTIVE: The technical objective of this project is the fabrication of a miniaturized Thermoacoustic Refrigeration (TAR) device compatible with operation at elevated pressures. To enable this evaluation, the Naval Postgraduate School (NPS) will build in accordance with Rockwell Science Center (RSC) specifications and deliver to RSC a functional miniature TAR prototype capable of operating at elevated pressures. RSC is pursuing separate R&D activities complementary to the proposed work, and the elevate-pressure prototype will be used by RSC for comparison with the results of alternative research and development efforts being pursued by RSC, to provide quantitative technical information on potential future paths for performance enhancement.

DoD KEY TECHNOLOGY AREAS: Other (Thermo-Acoustics)

KEYWORDS: Miniaturized Thermoacoustic Refrigeration

REMOTE IDENTIFICATION OF EXPLOSIVES

LCDR Daphne Kapolka, USN, Assistant Professor
Department of Physics
Sponsor: Unfunded

OBJECTIVE: To explore current and future capabilities for the remote detection of explosives in support of force protection.

SUMMARY: The October 2000 attack on the *USS COLE* underscored the need for force protection from asymmetric threats carrying high energy conventional explosives. In this project, the feasibility of the remote detection of explosives in support of force protection is examined. A draft Mission Needs Statement (MNS) and a Concept Exploration of the most promising technologies and means of employment are included in the report. Based on figures obtained from landmine flux rates, rough estimates of the concentration of TNT vapor expected downwind from a source are calculated based on atmospheric dispersion and diffusion models. The vapor concentration expected from a sample of TNT with a surface area of 1000 cm^2 at 21-23^oC is estimated to fall to as low as 10^{-18} mol/cc within one meter of the source. Due to the extreme drop-off in concentration with range, sensors are envisioned to be deployed on Micro Unmanned Aerial Vehicles (MAV) for transport to suspect boats. Eight sensor types were examined for their potential in meeting this detection challenge. Chemiresistor and fluorescent polymer detectors, nuclear quadropole resonance, ion mobility spectroscopy, infrared/ultraviolet/visible spectroscopy, gas chromatography combined with surface acoustic wave sensors, and the Jaycor spectrophone were evaluated for both current capability and the potential for improvements. None of the sensors currently available are able to detect explosive vapors remotely at the concentrations expected. However, the polymer-based microchip sensors are judged to show the most promise for both increased detection limits and miniaturization. Such microchip sensors could be mounted on a MAV for transport to a suspect boat. For truly remote detection, the most promising technology examined was the Differential Absorption LIDAR (DIAL) method. This method seeks to cancel out the background noise through a differential measurement of the atmospheric absorption in a range of precise frequencies of laser light. Further research is recommended to more precisely quantify the concentrations of explosive vapors expected and to determine the potential for increased sensitivity in each of the sensor types.

PUBLICATIONS:

Colpo, D.J., Ferguson, K.L., O'Malley, S.P., Rutherford, S.M., Stetson, S.W., Varnedore, P. and Kapolka, D., "Remote Identification of Explosives (RIDEX), Mission Need and Concept Exploration," Naval Postgraduate School Technical Report, NPS-PH-01-003PR, August 2001.

DoD TECHNOLOGY AREA: Other (Force Protection)

KEYWORDS: Explosive Detection, Asymmetric Threat, TNT, Conventional High Energy Explosives, Trace Gas Detection

OPTICAL SENSORS OPERATING SIMILAR TO BIOLOGICAL VISION SYSTEMS

Gamani Karunasiri, Associate Professer
Department of Physics
Sponsor: Naval Postgraduate School Research Initiation Program

OBJECTIVE: The objective of the proposed research is to investigate novel sensor concepts using multi-layer semiconductor structures.

SUMMARY: A multi-layer semiconductor device was successfully developed to convert incident light to a series of large voltage pulses. The frequency of the pulsed was found to be proportional to the intensity of the incident light. The generation of pulses using the multi-layer device was simulated using PSPICE to optimize the device parameters. A patent application has been filled based on the initial findings. In addition, experimental studies were also carried out to probe the optical transitions in quantum well and quantum dot structures and a dual-band quantum well detector structure has been designed for the application in laser-guided weapons.

PUBLICATIONS:

Zhou, L., Karunasiri, G. and Chee, Y.H., "Measurement of Excited State Position of Bound-to-Bound Quantum Well Infrared Detectors," *Journal of Applied Physics*, Vol. 90, pp. 2045-2047, 2001.

Teo, K.L., Qin, L., Noordin, I.M., Karunasiri, G., Shen, Z.X., Schmidt, O.G., Eberl, K. and Queisser, H.J., "Effects of Hydrostatic Pressure on Raman Scattering in Ge Quantum Dots," *Physics Review, B*, Vol. 63, pp. 1-4, 2001.

Mei, T. and Karunasiri, G., "Investigation on Two-color Detection using Asymmetric InGaAs/GaAs/AlGaAs Multiquantum Wells with Superlattice Barriers," Asia-Pacific Optical and Wireless Communications Conference, Beijing, China, 11-15 November 2001.

Qian, X., Xu, Y.P. and Karunasiri, G., "A Tunable Bias-heating Cancellation Circuit for Microbolometer Readout Electronics," SIcon'01 Sensors for Industry Conference, Rosemount, IL, 5-7 November 2001.

Zhou, L., Akkipeddi, R., Cheah, C.W. and Karunasiri, G., "Diffraction Grating for Middle Wavelength and Long Wavelength Quantum Well Infrared Detectors," International Conference on Materials for Advanced Technologies, Singapore, 1-6 July 2001.

Ng, M.W., Chee, Y.H., Karunasiri, G. and Xu, Y.P., "On-Chip Compensation of Dark Current in Infrared Focal Plane Arrays," 2001 IEEE International Symposium on Circuits and Systems (ISCAS'2001), Sydney, Australia, 6-9 May 2001.

PRESENTATIONS:

Cheah, C.W., Tan, L.S., Zhou, L.F. and Karunasiri, G., "Experimental Measurement of Intersubband Transitions in GaAs/InGaAs/AlGaAs Step Multiple Quantum Wells and Comparison with Theory," Sixth International Conference on Intersubband Transitions in Quantum Wells, Asilomar, CA, 10-14 September 2001.

PATENTS:

Karunasiri, G., "Artificial Neuron Using Semiconductor Controlled Rectifier," Naval Postgraduate School, 2001, submitted.

THESIS DIRECTED:

Stetson, S.W., "PSPICE Modeling and Parametric Study of Microbolometer Thermal Detectors," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREA: Sensors, Electronic Warfare

KEYWORDS: Photoreceptors, Biological, Multi-Color IR Sensors, Quantum Well Detectors

LASER PLASMA RADIATION SOURCE DEVELOPMENT

William L. Kruer, Professor
William B. Maier, Senior Lecturer
Department of Physics
Sponsor: Defense Threat Reduction Agency

OBJECTIVE: The overall objective of this program is the continuation of a multi-year effort to perform a series of laser-plasma experiments and calculations designed to develop laser-plasma x-ray source for NWET. The Naval Postgraduate School's (NPS) collaboration with the University of California, Los Angeles (UCLA) Physics Department will design, model and evaluate the ability of multiple frequency laser light to generate abundant hot x-rays for simulating and stimulating various nuclear weapons related effects.

DoD KEY TECHNOLOGY AREAS: Other (Nuclear Weapons)

KEYWORDS: Lasers, Plasmas, X-Ray Sources

ENVIRONMENTALLY ADAPTIVE SONAR TECHNOLOGIES

Andrés Larraza, Associate Professor
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: To examine Navy relevant applications of the phenomenon of time-reversal acoustics. This phenomenon takes advantage of the incorporation of waveguide effects into the acoustic field to adaptively remove the influence of the environment through re-transmission of a time-reversed transmission. Considered as part of this project were enhancements to active sonar detection algorithms and underwater acoustic communication systems.

SUMMARY: Research topics have included time reversal acoustic applications to active sonar enhancement and underwater acoustic communications, environmentally adaptive communication techniques, and general studies of shallow water influences on communication and sonar system performance. Studies with different noise levels showed time reversal to be a very robust technique for sonar enhancement. In fact, time reversal techniques proved to enhance the sonar signal by 4 dB, at a signal to noise ratio of 0 dB. Tests of Time Reversal Approach to Communications (TRAC) against Match Environment Signaling Scheme (MESS) were conducted, indicating that the MESS approach may be more promising than the TRAC approach. Numerical analysis of source-induced Doppler effects on underwater communication have also been performed. Research included theoretical, numerical, and experimental aspects of the underwater acoustic problem. Experimental studies of full-duplex communications in a shallow water channel have been successfully conducted, showing higher data transmission rates.

PUBLICATIONS:

Heinemann, M., Larraza, A. and Smith, K. B., "Acoustic Communications in an Reverberant Environment Using Single–Channel Time–Reversal Acoustics," *Applied Physics Letters*, Vol. 80, pp. 693-695, 2002.

Smith, K.B., "Computing the Influence of Doppler due to Source/Receiver Motion in Parabolic Equation Models," *Journal of Computational Acoustics*, (accepted).

Smith, K.B., Larraza, A. and Kayali, B., "Scale Model Analysis of Full-Duplex Communications in an Underwater Acoustic Channel," *Proceedings of Oceans 2001 Conference*, Honolulu, HI, 5-8 November 2001.

M. Heinemann, A. Larraza and K. B. Smith, "Experimental Studies of Applications of Time–Reversal Acoustics to Non-Coherent Underwater Commu nications," *Journal of the Acoustical Society of America,* submitted.

Smith, K.B., Abrantes, A.A.M. and Larraza, A., "Examination of Time-Reversal Acosutics in Shallow Water and Applications to Noncoherent Underwater Acoustic Communications," *Journal of the Acoustical Society of America,* submitted.

PRESENTATIONS:

Larraza, A. and Smith, K., "Time Reversal Acoustics, Sonar and Acomms Applications Demonstrated in Tank Scale Experiments," ONR Peer-Review, San Diego, CA, 12-13 June 2001.

Larraza, A., "Applications of Time-Reversal Acoustics to Mine Warfare, Sonar Technology, and Underwater Acoustic Communications," Stanford University, 31 July 2001.

Larraza, A., "Tank-Scale Experiments on Applications to Time-Reversal Acoustics," Workshop on Inverse Problems and Applications, Mathematical Science Research Institute, Berkeley, CA, 14-15 November 2001.

THESES DIRECTED:

Athanasiou, C., "Evaluation of Alternative Communication Schemes Using Environmentally Adaptive Algorithms," Masters Thesis, Naval Postgraduate School, June 2001.

Houdeshell, J., "Analysis of Optimal Operating Parameters for Shallow Water Acoustic Communications," Masters Thesis, Naval Postgraduate School, March 2001.

Stokely, J., "Experimental Studies of Two-Way Single Element Time Reversal in a Noisy Waveguide," Masters Thesis, Naval Postgraduate School, June 2001

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Modeling and Simulation

KEYWORDS: Underwater Acoustic Communication, Littoral Environments, Time-Reversal Acoustics

TARGETING ACCURACY FOR NIIR SYSTEMS

Andrés Larraza, Associate Professor
Department of Physics
Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: Non-imaging Infrared (NIIR) systems are a primary tool in the area of missile defense and related technologies. One ongoing problem has been the pointing accuracy of such systems, and in

particular geolocation of small (often sub-pixel) targets. A proposed approach to this problem is to place a laser beacon in-scene as a reference. Such a device has been constructed, and work is underway to test the technology.

SUMMARY: The laser beacon prototype (LBP) development effort has to date occurred over a roughly four year period, including design, manufacture, integration, and deployment into a stressing field environment for testing. The LBP design includes an optical parametric oscillator, integrated pointing optics, and associated support equipment. The tracking system of the LBP has shown two main problems: (1) An inability to track a slow moving target without feedback. There was typically a complete loss of alignment in about 2 minutes. (2) Alignment repeatability problems. The LBP was realigned to match a test sequence, with realignments occurring at 5 to 30 minute intervals. The required adjustments were nearly random between tests. The LBP has been transferred to NPS from Raytheon in order to address these problems. NPS diagnosed the cause for these symptoms (by conducting alignment tests on the gimbal, the software tracking routines, and the laser), and provided solutions that can be implemented in future software designs.

THESES DIRECTED:

Herrmann, C., "Targeting Accuracy for Non-Imaging Infrared Systems," Diplomarbeit Im Fach Mess-Und Informationstechnik, Universität der Bundeswehr Hammburg, April 2001.

DoD KEY TECHNOLOGY AREAS: Remote Sensing

KEYWORDS: Non-Imaging, Infrared, Satellite Illumination, Tracking

THERMODYNAMICS OF INFORMATION FOR THE DISA/NSA JOINT THERMONATOR PROJECT

James H. Luscombe, Professor
Department of Physics
Sponsor: Defense Information Systems Agency

OBJECTIVE: Identify state spaces with special focus on relevance to the warfighter. Develop associated processes and software. Initial data collection. Use existing solutions from statistical PHSIS to analyze and understand networks thermodynamic signal and correlation of equilibrium and nonequilibrium fluctuations with normal and anomolous traffic. Investigate and verify degree of theoretical and mathematical similarity between the state space dynamics of information systems and physical systems. Streamline procedures for rapid identification of traffic anomalies using existing statistical physical techniques, deliveries.

DoD KEY TECHNOLGY AREAS: Computing and Software

KEYWORDS: Information Systems, Physical Systems

STUDY OF SEISMIC SONAR DEMONSTRATIONS FOR THE DETECTION OF BURIED MINES IN AMPHIBIOUS WARFARE SCENARIOS

Thomas G. Muir, Research Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: Prepare seismic sonar technology for the projection of Naval power ashore.

DoD KEY TECHNOLOGY AREAS: Other (Mine Countermeasures)

KEYWORDS: Seismic Sonar, Rayleigh Waves, Mine Detection, Mine Avoidance, Mine Clearance

ADVANCED SENSOR RESEARCH-SPECTRAL/TEMPORAL APPLICATIONS

R. Chris Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

OBJECTIVE: The proposed effort is to support the NRO in MASINT research and development efforts, particularly in the area of high frame rate systems.

SUMMARY: Analysis was completed on multi-system fusion, and high accuracy rates were obtained in scene classification.

THESIS DIRECTED:

Alfieri, J., "Terrain Categorization Using Multitemporal Infrared Imagery," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Other (Remote Sensing)

KEYWORDS: Environmental Monitoring, Remote Sensing

CENTRAL MASINT ORGANIZATION R&D TECHNICAL ASSISTANCE

R. Chris Olsen, Associate Professor
Department of Physics
Sponsor: Defense Intelligence Agency

OBJECTIVE: The proposed effort is to support the Central MASINT organization in its research and development efforts, particularly in the area of spectral imagery and high frame rate non-imaging infrared systems. Technical development of the Cobra Brass F System, exploitation of Cobra Brass F data and development of a UV spectral imager are supported.

SUMMARY: Significant progress was made with the Cobra Brass studies, including work in target tracking and aerosol discrimination. Work on a new UV spectrometer was begun. A two-day workshop was held on the problem of detecting chemical and biological agents.

DoD KEY TECHNOLOGY AREAS: Other (Remote Sensing)

KEYWORDS: Environmental Monitoring, Remote Sensing

RADIANT BRASS EXPLOITATION

R. Chris Olsen, Associate Professor
Philip L. Walker, Research Associate Professor
Department of Physics
Sponsor: Measurements and Signal Intelligence Office

OBJECTIVE: The objective is to construct and validate algorithms for using a DoD satellite (DoDSat) to predict EO performance in the desert. Two algorithms were in mind. The first is to apply an algorithm developed previously for use with AVHRR that relies on loss of contrast between light and dark areas. The second approach is to adapt to DoDSat an algorithm developed for the NASA MISR sensor. MISR photographs a ground site from several angles as it passes over it. Differing ground contrast per slant path is used to extract atmospheric optical depth. DoDSat will also achieve slant path variation due to its orbital motion. The advantage of the MISR algorithm is that inherent ground albedo may not need to be known in advance.

SUMMARY: This project was funded for $100K starting 1 May 2001. This project will be completed FY 02. We have collected 20 DoDSat shots of the Naval Air Warfare Center, China Lake, California coincident with times at which our ground equipment was working. Several of those images were double-angle shots taken from slightly different locations in the satellite orbit. The ground equipment is located in the Indian Wells Valley several miles from the Naval Air Station at China Lake. The equipment has been kept operational 80% of the time this past year. This high coverage allows us to ground-truth AVHRR, the MISR sensor on Terra and other NASA satellite-derived optical depths yielding indirect comparisons with DoDSat. There are also two shots of NAS Fallon, Nevada taken nearly coincident with FLIR range data obtained using a CIRPAS Altus UAV. Extinction measurements obtained from DoDSat are used as input to the TAWS FLIR code for comparison of satellite computed and measured FLIR performance.

The atmospheric optical depth retrieval algorithm developed by Professor Durkee (NPS Meteorology Department) for AVHRR is being applied to DoDSat. DoDSat retrieved optical depths are validated using ground-based measurements from the site at China Lake. The China Lake instruments are operated continuously (24x7) obviating the need for coordination with satellite over-flights. Ground data has been collected for over a year and the investigators plan to continue doing so until the end of FY 2002. This will allow ground-truth more satellite retrievals including, possibly, more DoDSat measurements. More double angle measurements are desired, but otherwise have a workable amount of data in hand. There is also an interest in the MISR retrievals, which are available on the Web, because they use a completely different algorithm than that used for AVHRR/ DoDSat retrievals; thereby, providing a cross-check.

Extinction is the quantity needed for predicting FLIR performance. Extinction is found by dividing satellite-derived optical depth by the height of the atmospheric mixing layer. This height can be obtained from radiosonde balloons, when they are available, or artificial radiosonde profiles obtained from Numerical Weather Prediction (NWP) codes. In practice, for locations where radiosonde data are not available NWP programs are the only way to get radiosonde profiles. Artificial radiosonde profiles are generated with the MM5 NWP code. These profiles are basically interpolations between radiosonde data obtained from irregular launches made at from China Lake; whereas, radiosonde profiles must be generated completely artificially at NAS Fallon, Nevada. In collaboration with CIRPAS we have collected some simultaneous DoDSat and FLIR range detection data using their Altus UAV at NAS Fallon yielding the direct measure of actual and satellite predicted FLIR performance that we seek. An alternate way to obtain the thickness of the haze layer is by estimating its temperature. It might be possible to make this estimate using the mid-wave band.

In collaboration with China Lake a "Multi-Filter Rotating Shadow Band Radiometer," MFR-7 and three aerosol sizers are operated at China Lake. The MFR-7 directly measures the optical depth of the atmosphere from ground to space providing an almost direct band-for-band comparison with DoDSat-derived optical depths in the coincident parts of their response spectra. Aerosol size measurements from the three particle sizers along with Mie calculations are used to extend the spectral comparison. NAWC also shares data from two nephelometers and other air quality instruments and meteorology instruments providing. The MFR-7 and sizer data are transmitted to NPS periodically. Other data are supplied to NPS quarterly via a contractor.

PUBLICATION:

Walker, P. and Blomshield, F., "Optical Characteristics of Desert Dust," *Proceedings of SPIE*, Vol. 4718, Orlando, FL, April 2002.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Environment, Transmission

RESEARCH IN SPECTRAL TEMPORAL IMAGING
R. Chris Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

OBJECTIVE: The proposed research is in the development of spectral, polarimetric and high temporal resolution systems. Exploitation of NTM data is supported, along with exploitation of NIIR data.

SUMMARY: Analysis was completed on multi-system fusion, and high accuracy rates were obtained in scene classification.

THESIS DIRECTED:

Reese, J., "Terrain Categorization Using Multitemporal Synthetic Aperture Radar (SAR)," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Other (Remote Sensing)

KEYWORDS: Environmental Monitoring, Remote Sensing

TERRAIN CATEGORIZATION VIA SENSOR FUSION
R. Chris Olsen, Associate Professor
Department of Physics
Sponsor: National Reconnaissance Office

OBJECTIVE: The proposed research is to study the utility of data from national technical means (NTM) for terrain categorization (TERCAT). Data from visible, IR and radar systems have been acquired in modes available to operational users, and will be analyzed according to the techniques currently in use for the interpretation of spectral imagery.

SUMMARY: Analysis was initiated on a project exploiting NTM for the problem of Naval Order of Battle (NOB). The primary purpose is to support the counter-drug efforts at JIATF-East. Data analysis procedures were begun.

DoD KEY TECHNOLOGY AREAS: Other (Remote Sensing)

KEYWORDS: Environmental Monitoring, Remote Sensing

REVERBERATION MODELING AND DATA ANALYSIS IN ASIAEX
Kevin B. Smith, Associate Professor
Department of Physics
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this research was to model the influence of propagation on both interface and volume reverberation over a large bandwidth of frequencies, examine the spatial correlations of the predicted reverberant signal, and compare such predictions with data collected in the ASIAEX experiments. By understanding the role of the acoustic propagation in such signals, a more clear description of the underlying dominant scattering mechanisms should emerge. This may also provide important information on the statistics of the signal, enhancing the use of active systems by accounting for some of the reverberation structure in the signal processing.

SUMMARY: The theoretical development of the PE reverberation model was expanded to incorporate density fluctuations in the sediment volume. Both interface roughness and sediment sound speed and density fluctuations were computed based on characteristic spectral models of such perturbations. These

were incorporated into the PE model, and solutions of the acoustic propagation for both CW and broadband pulse sources were generated. During this development portion, only a single realization for both the interface and volume fluctuations was used in order to concentrate on the processing algorithms. The rms fluctuation of the interface was set to 1m while the volume sound speed rms fluctuation was fixed at 15m/s. The density perturbations scaled appropriately with sound speed fluctuations. Both interface and volume perturbations were included in all calculations, although the reverberation due to each was considered separately. Thus, it is possible that one type of perturbation may dominate the structure of both types of reverberation.

From both CW and broadband calculations, vertical spatial correlations of the reverberation field were computed. Additionally, the statistical characteristics of the reverberation signal were examined. It was found that the introduction of density fluctuations decreased returns from long range due to the resultant additional forward scattering. However, the structures of the returns remained very similar, due to the correlation between sound speed and density perturbations in the volume. It was also found that the vertical structure of the signals was less coherent for the volume returns than for the interface. Further examination of this effect will occur in FY02. Spectral analysis of the signals did not reveal any apparent relationships between the perturbations and the reverberation structure. This will also be investigated further in the future.

PUBLICATIONS:

Smith, K.B., Li, L.-S., Lee, B.-C. and Kao, H., "Sediment Interface and Volume Reverberation Modeling with The Parabolic Approximation," *Journal of the Acoustical Society of America*, Vol. 110, pp. 2743, 2001.

THESIS DIRECTED:

Kao, H., "Numerical Analysis of Bottom Reverberation and the Influence of Density Fluctuations," Masters Thesis, Naval Postgraduate School, December 2001.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Shallow Water Reverberation, Parabolic Equation Modeling